Bringing Higher Performance in Broadband with Less Power

BB Europe 2007

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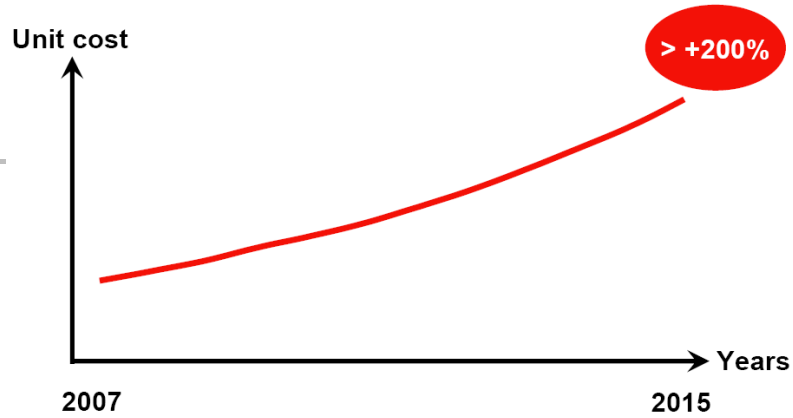
Agenda

1. Intro
   - Why
   - Examples
2. Evolution of Power consumption of a DSLAM
3. New line driver technology
4. New Initiatives
5. New network topology
6. Conclusion

Why is power reduction important



For the operator

- Reduces the energy cost

  By 2015 up to 50 TWh of electricity is required per year for Broadband communication (Code of Conduct on Energy Consumption for Broadband equipment)

- Reduces the cost for cooling and air-conditioning and allow for fresh-air cooling

For the equipment manufacturer

- Allows further density increase

  Now limited by thermal and power limitations

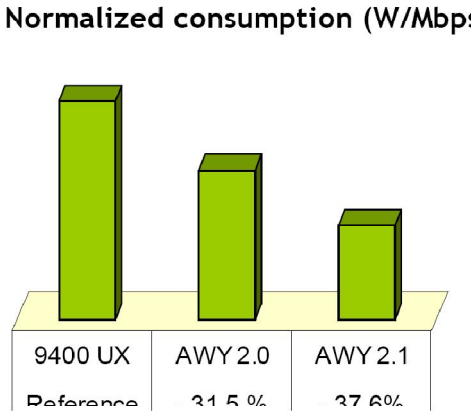
For the Environment

- Global warming…

Examples of power reduction

Microwave transmission – AWY

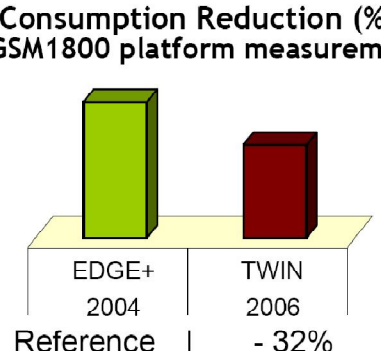
New generation HW design improves the power consumption per equivalent transceiver



GSM Base Station – TWIN TRX

Capacity mode: Increased integration

- 1 TWIN module = 2 functional TRX
- Higher capacity expansion possibilities without installing a larger cabinet
- Lower power consumption of the cabinet



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1. Intro
2. Evolution of Power consumption of a DSLAM
   - What is a DSLAM
   - DSLAM Architecture
   - DSLAM power evolution
   - DSLAM power Decomposition
3. New line driver technology
4. New Initiatives
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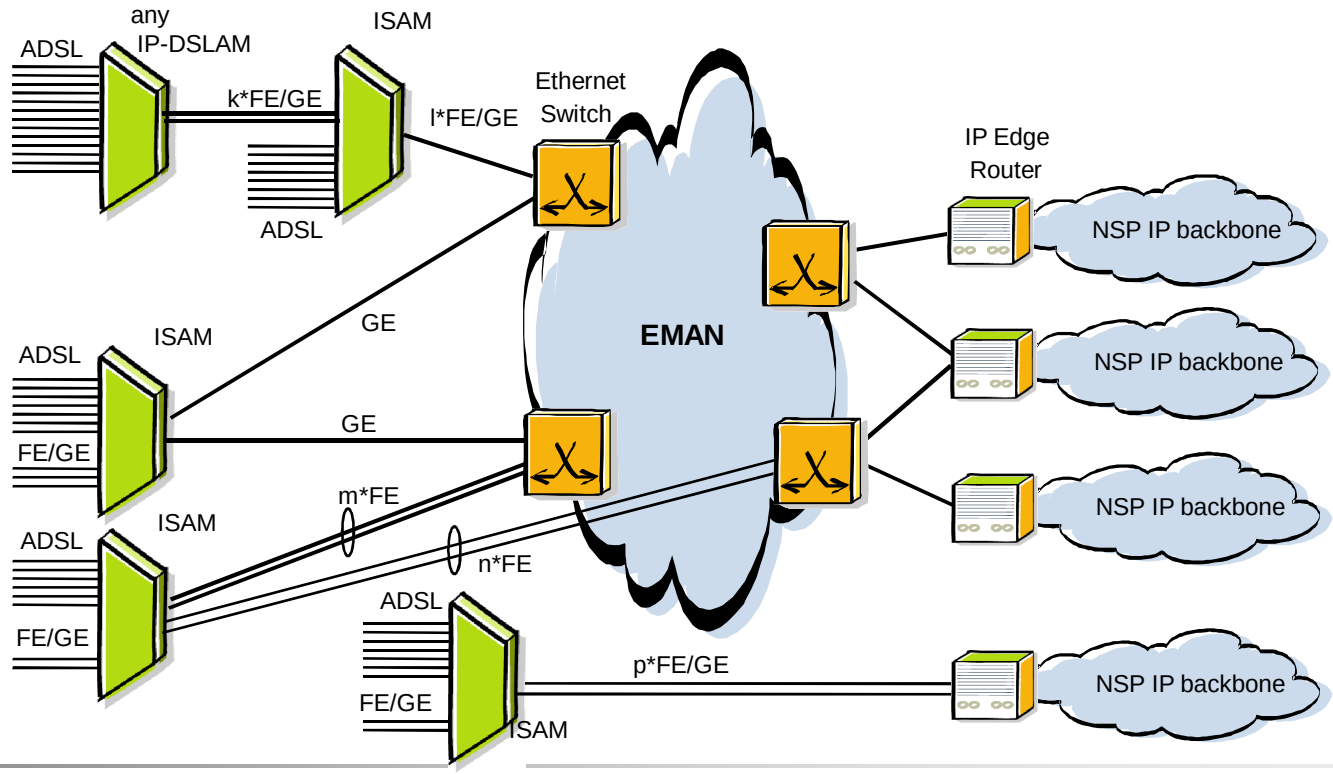
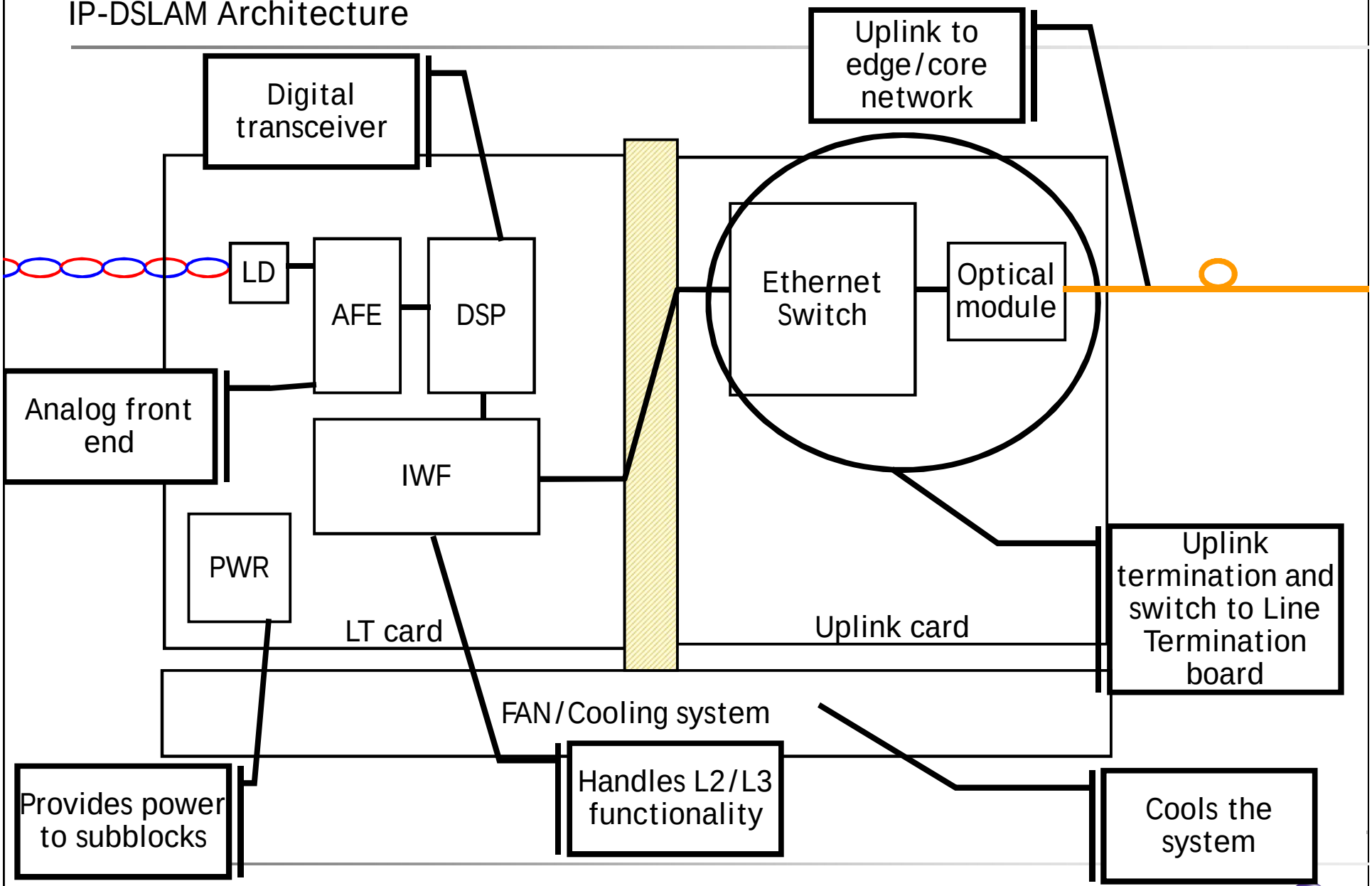
What is a DSLAM

Wikipedia

- Digital Subscriber Line Access multiplexer
- DSLAMs connect DSL lines with some combination of Asynchronous Transfer Mode (ATM), frame relay or Internet Protocol networks to a high-speed Internet backbone



IP-DSLAM Architecture



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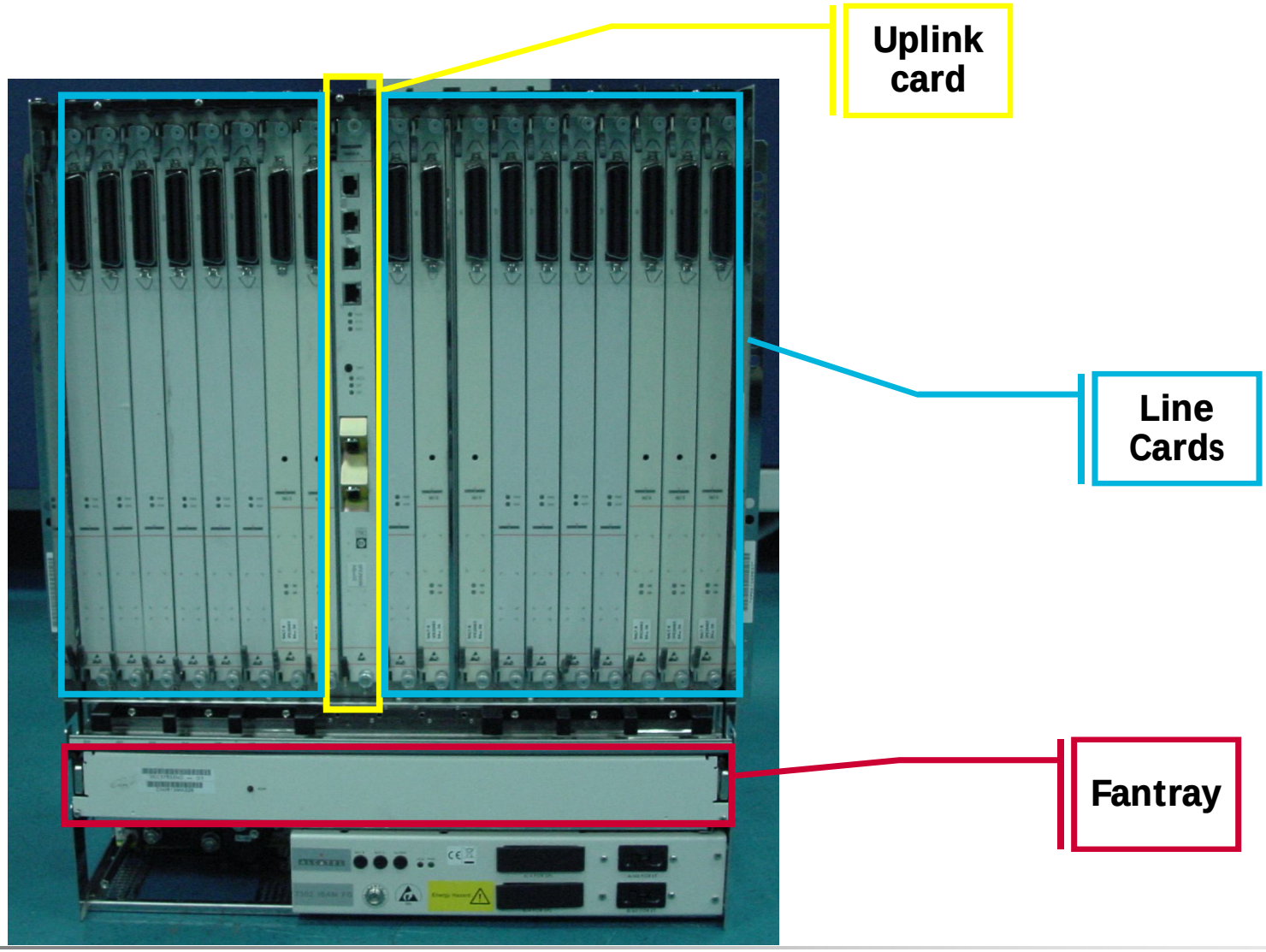
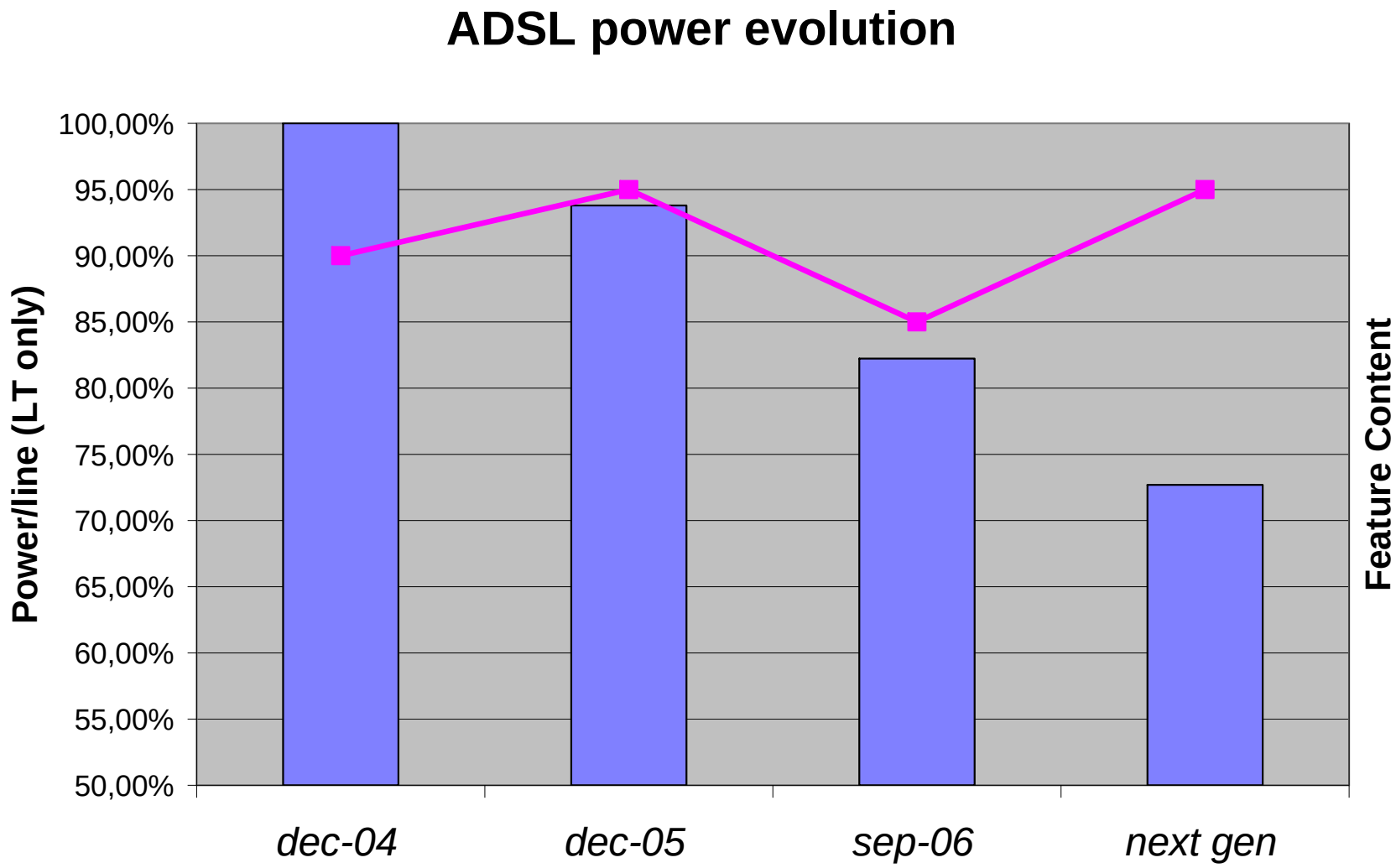
A DSLAM in real life



ADSL Power Evolution for Alcatel-Lucent IP-DSLAM



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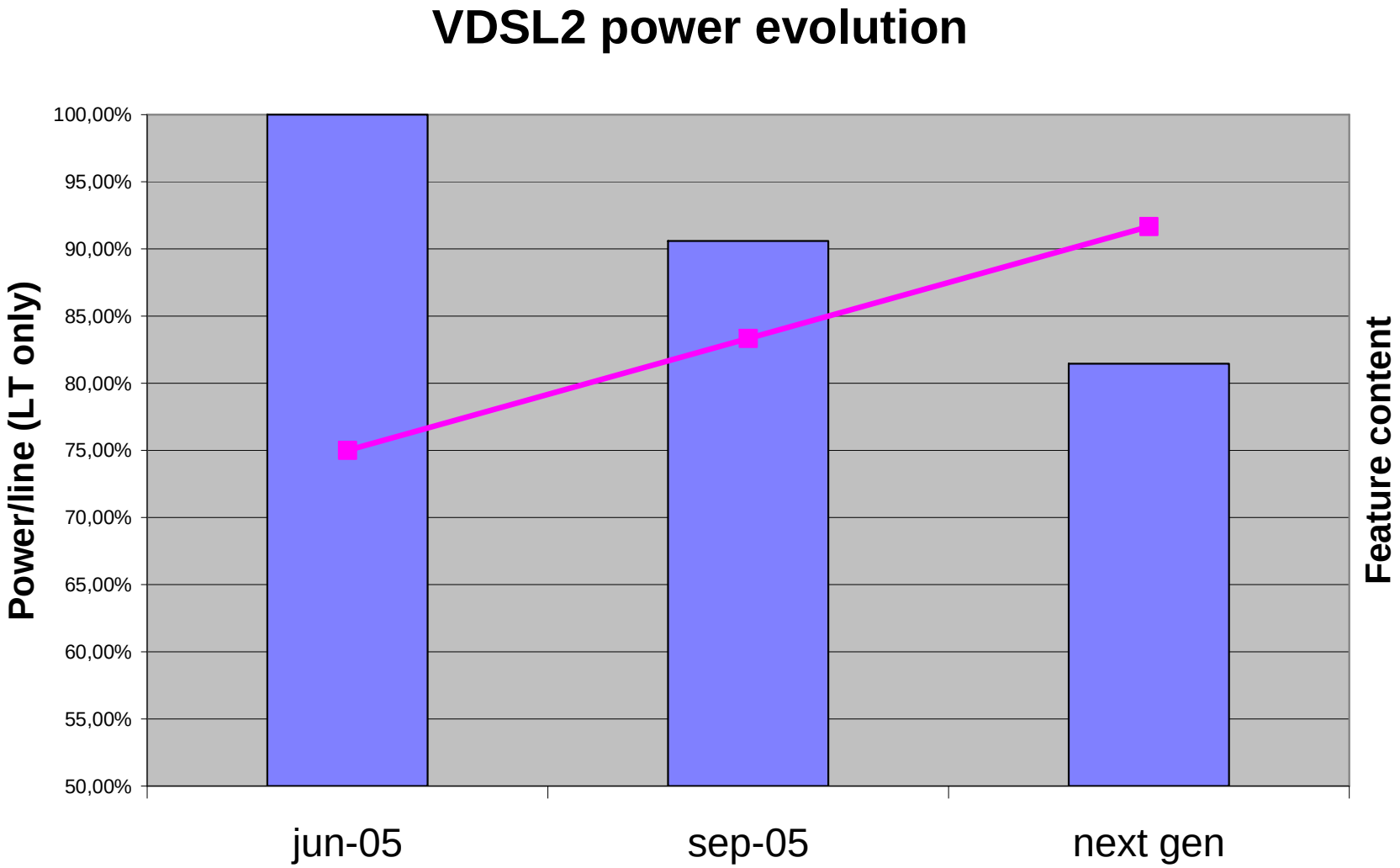
VDSL Power Evolution for Alcatel-Lucent IP-DSLAM



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Power Evolution of IP-DSLAM

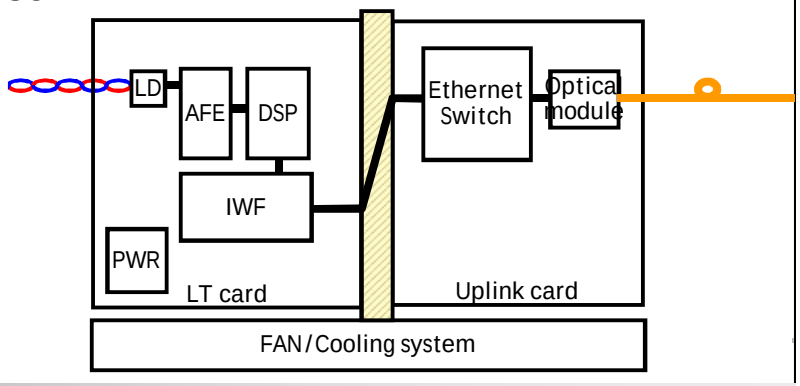
- Power consumption is decreasing

  Driven by

  – Further integration
  – Evolution of ASIC technology
    – 130 nm → 90 nm → 65 nm → 45 nm
  – Higher density
    – More lines per line card

  Despite increased functionality

  – Higher layer functionality
    – Not limited to L2 functionality
  – Increased Throughput per user
    – Peak and Sustained bandwidth per user
    – Speed-up of internal interfaces



Power Evolution of IP-DSLAM

- Can this evolution be sustained?

  Request for even higher guaranteed throughput per user

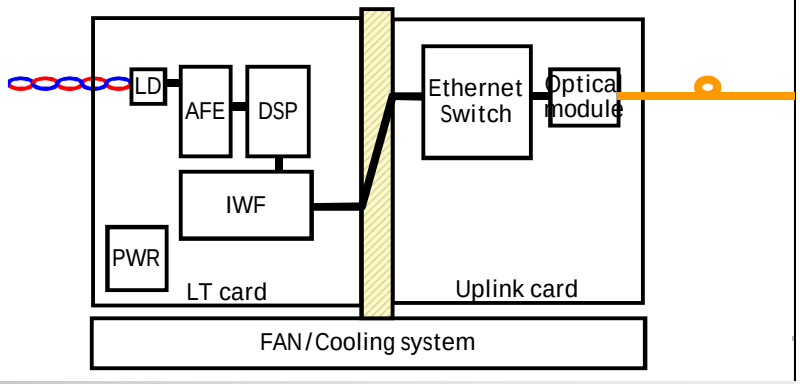
  – Upgrade of back plane throughput
  – Introduction of 10 Gbps interfaces

  Request for more functionality at the line card level

  – DSM Level 3
  – Routing functionality

  Are higher density line cards feasible?

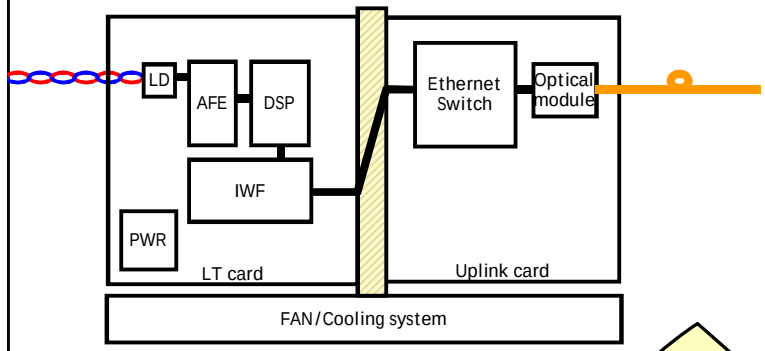
  – Board space is limited

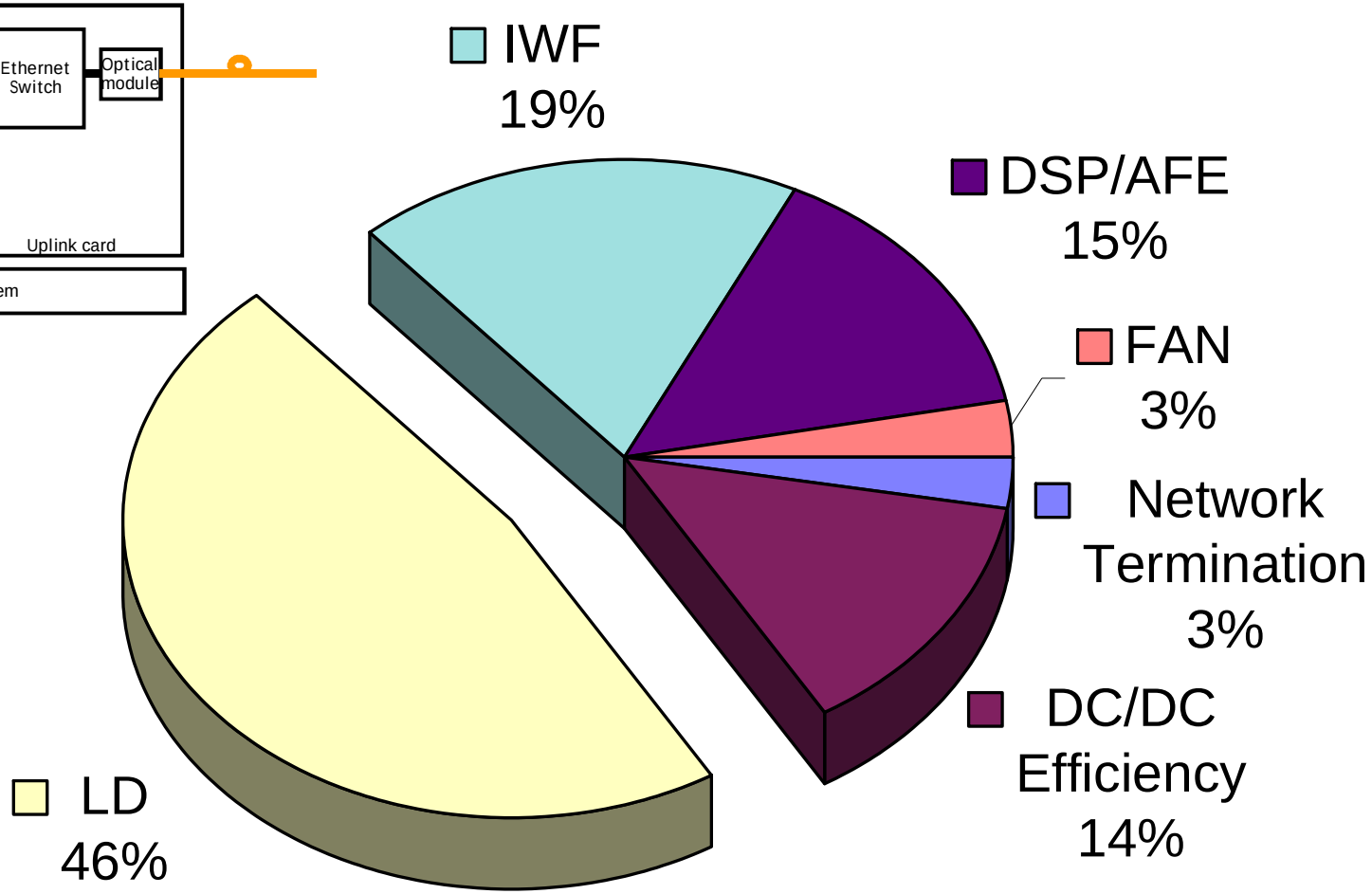


Power decomposition of IP DSLAM

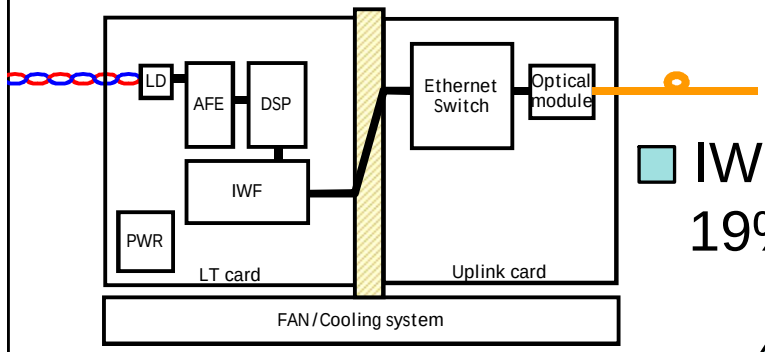
- Following figures show power decomposition of an IP-DSLAM
  - Full configuration
    - Max number of Line termination boards
    - Max density
    - No uplink card redundancy
    - Includes cooling solution
  - Worst case line conditions
- Power split up over
  - DC/DC efficiency
  - Cooling solution (FAN)
  - Uplink card
  - Inter working function
  - DSP/AFE
  - Line driver

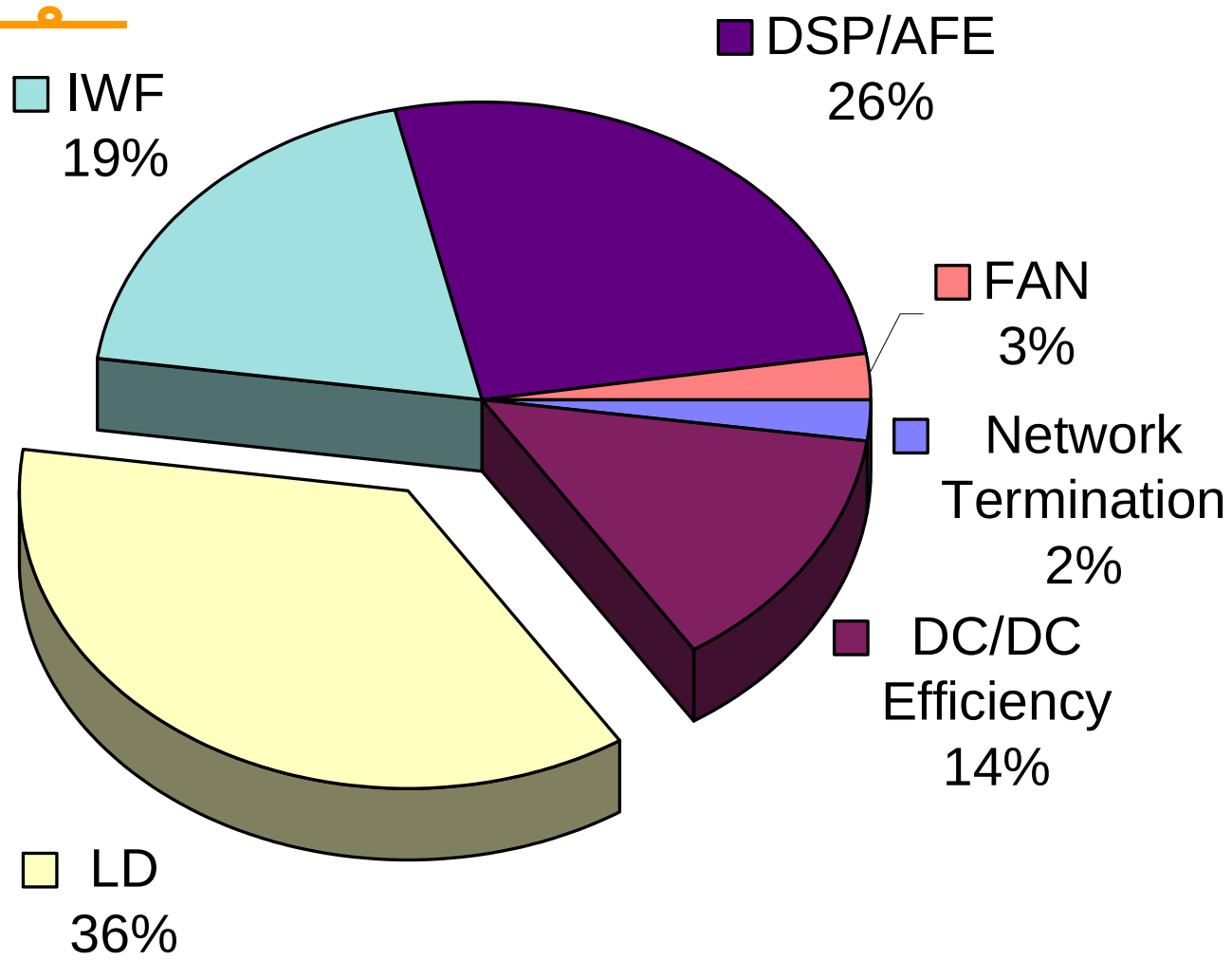
ADSL2+ IP DSLAM Power Decomposition





VDSL2 IP DSLAM Power Decomposition





IP DSLAM power decomposition

- Major power consumption contributors
  - Line driver
    - Up to 46 % for ADSL
    - Up to 36 % for VDSL2
  - DSP/AFE (DSL modem chipset, excluding Line driver)
    - 15 % for ADSL
    - 26 % for VDSL2
  - IWF (19 %)
- Line card functions account for majority of power consumption
- Line drivers still account for 1/3 to 1/2 of power consumption

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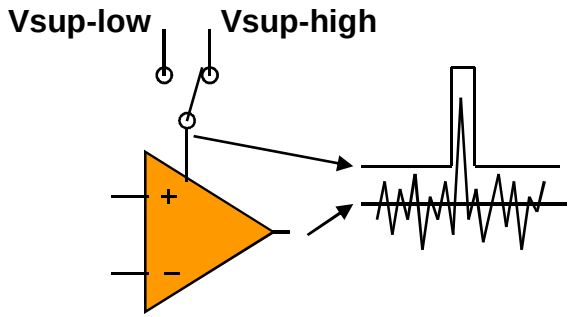
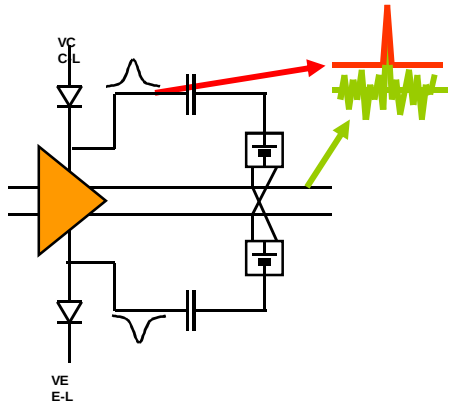
Linedriver technology

- Class AB line driver are most popular
  - Class AB refers to amplifier technology
  - Robust
  - Good performance
  - Max 15 to 20 % efficiency to be expected

Alternative solutions – Pro's and Con's

- Class D
  - + Very efficient (up 30 %)
  - - Not applicable for VDSL2/higher bandwidth
- Class G
  - + More efficient then class AB
  - + Should be applicable for both ADSL and VDSL2
  - - Requires more supply voltages, more complex board design
- Class H
  - + Similar efficiency as class G
  - + Does not require the second supply voltage from class G





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   - In Standardization
   - New techniques
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Why Standardization

Why is standardization important for (DSL specific) power reduction schemes

INTEROP

Overview of standardization initiatives

- EU Code of Conduct on Energy Consumption for Broadband equipment

  Initiated by the European Commission

  Voluntary basis

  Provides power consumption targets for CO and CPE

- ETSI EE

  Several initiatives within EE

  Technical Report (in progress)

  – Introduces Normalized Power Consumption (power consumption related to useful output)

  – NPC = Average Power Consumption [mW] / Useful output, i.e. Bitrate x distance [Mbps x km]

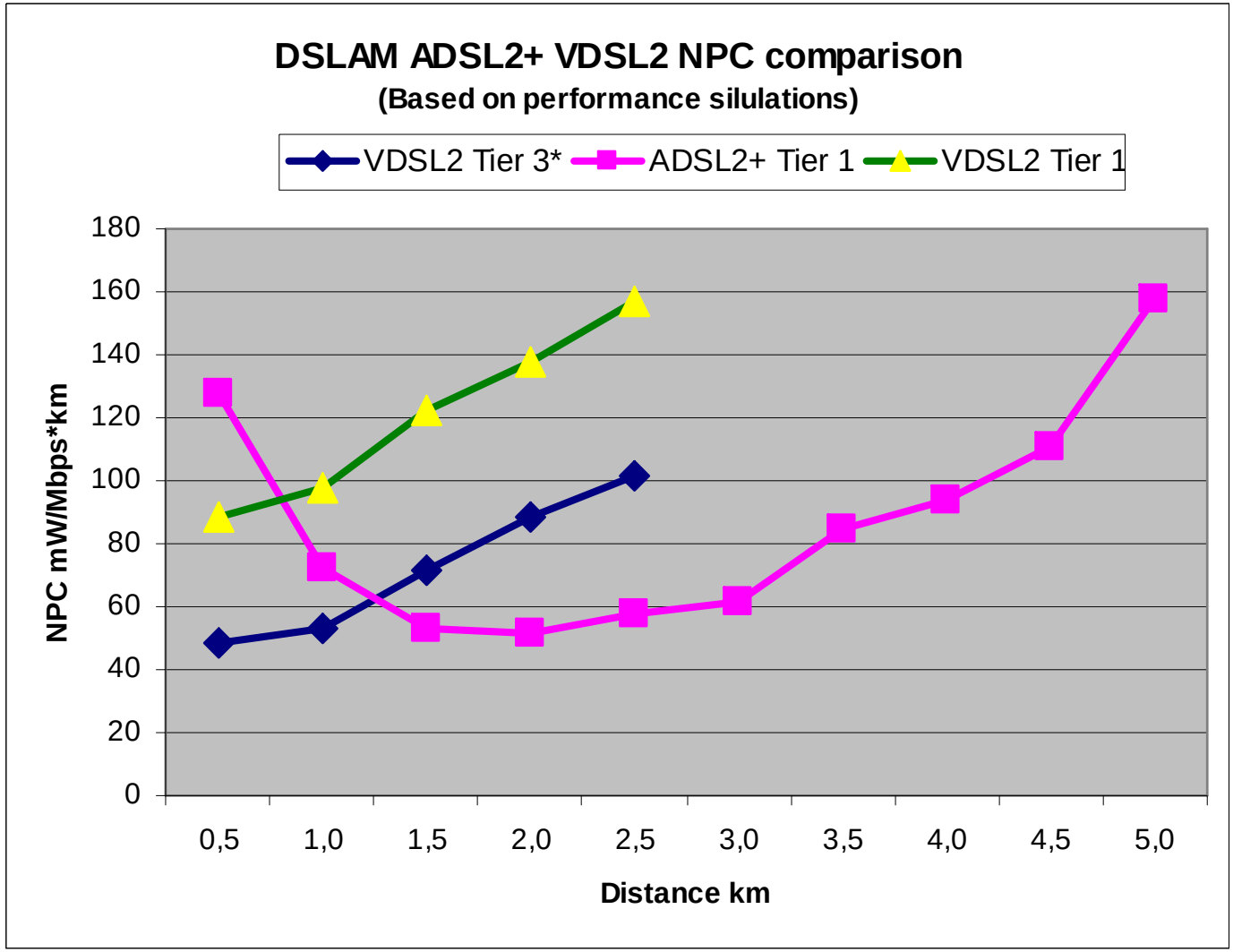
  Technical Specification (in progress)

  – Provides details on measurement setup and conditions

- ETSI TM6

  Study items on power saving

NPC example



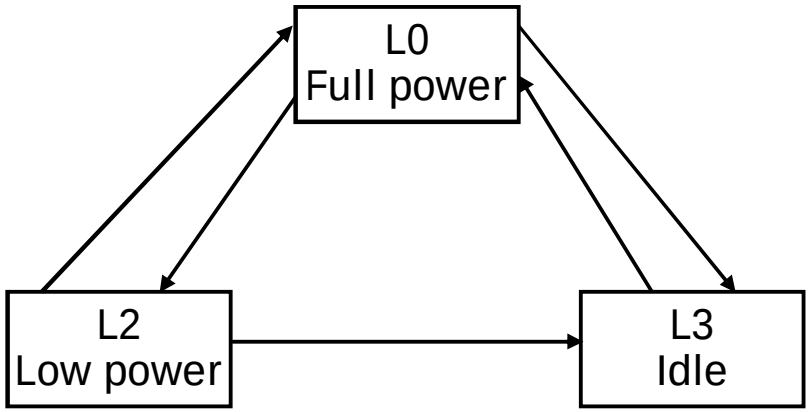
Extract from ETSI EE TR 102 530

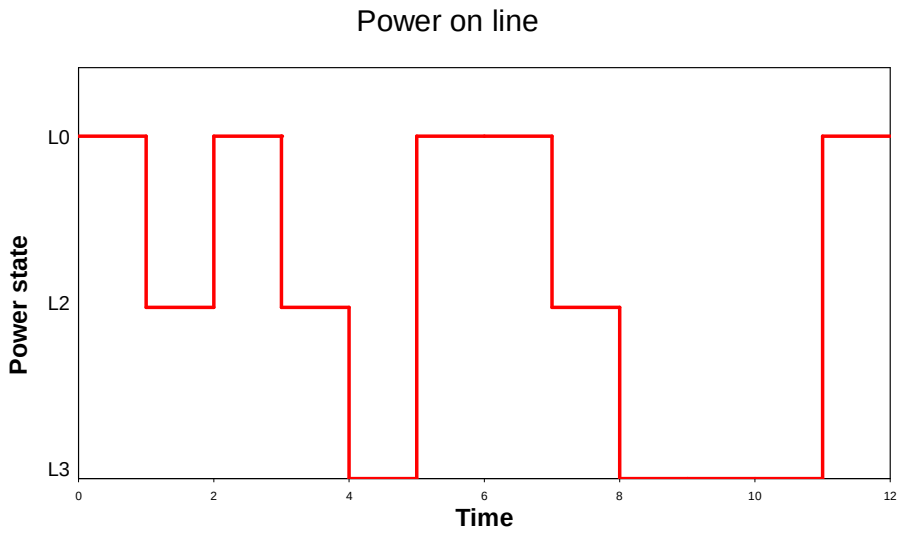
Physical layer power saving features

- ADSL2(plus)

  Defined in ITU-T ADSL2(plus) standard

  L2 low power state





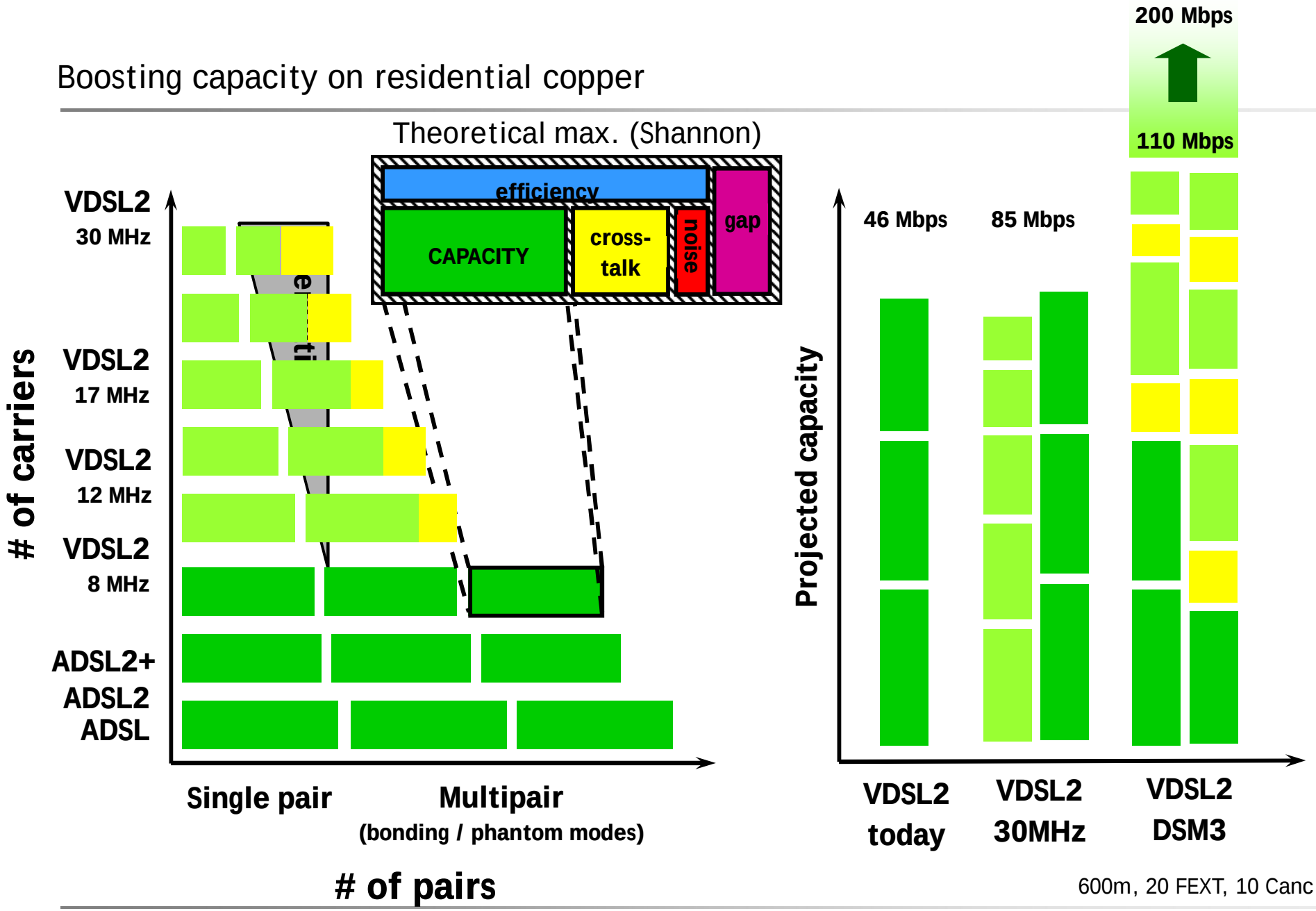
  Not widely used due to fluctuating crosstalk issues

- VDSL2

  Currently no power saving modes in standard

- New physical layer features under study which might result in power saving

Boosting capacity on residential copper



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Levels of DSM : definitions

- DSM level 0

  No coordination

- DSM level 1 - IWF = **SINGLE** user optimization

  Single user power allocation, Crosstalk Avoidance

- DSM level 2 - OSB = **MULTIPLE** user optimization

  Multi-user power allocation, Crosstalk Avoidance

  In practice: Alcatel-Lucent PSD Shaping

- DSM level 3

  Multi-user detection

  Crosstalk Precompensation (DS) and Crosstalk Cancellation (US)

How can DSM level 3 help in reducing power consumption

- More efficient use of the available spectrum

  Using the same line power, transport more bits

- Challenge

  Keep the processing requirements under control

  Current implementations/test platforms require extensive processing

  – Additional power consumption!

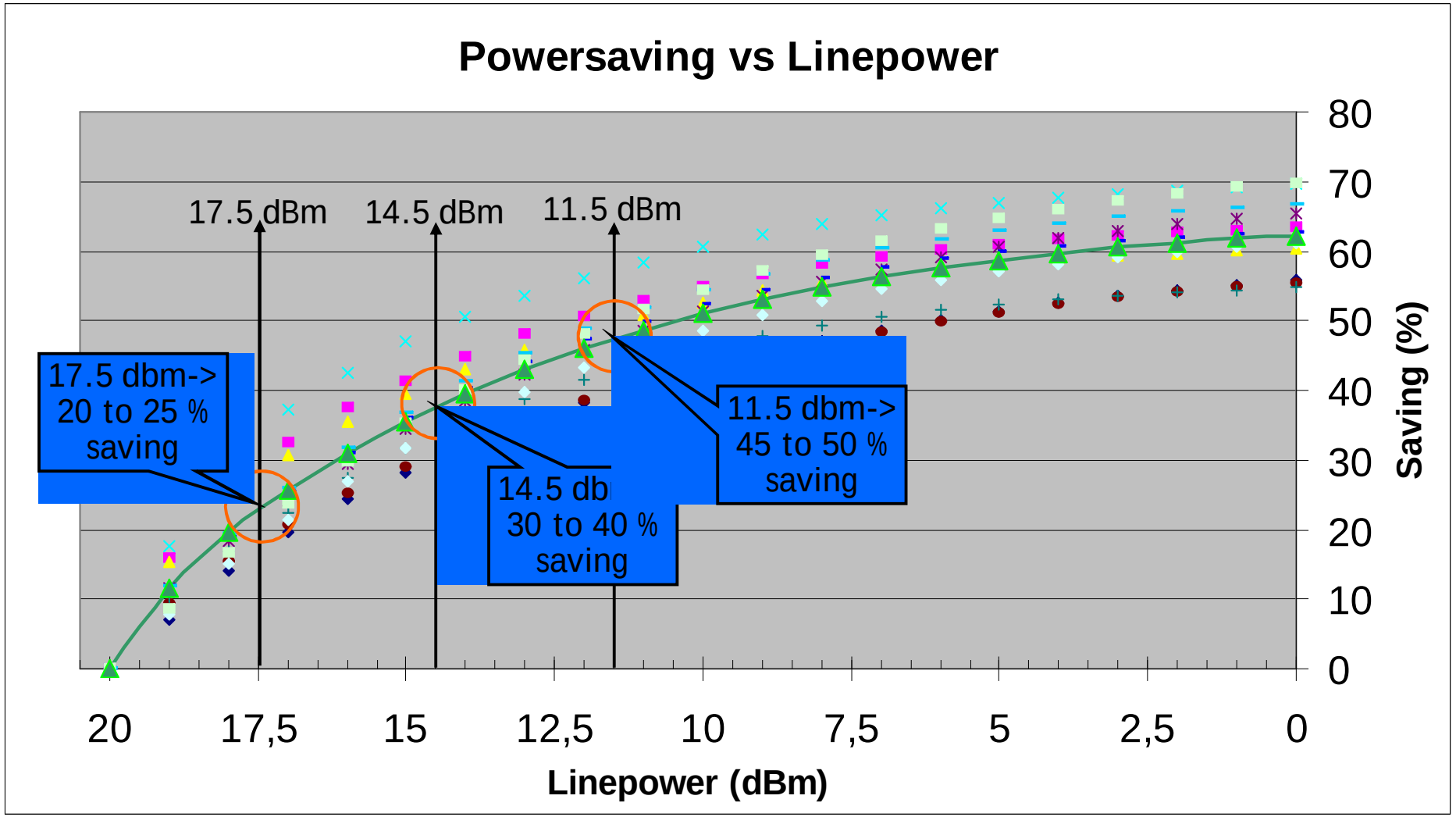
  Integrate this functionality in Digital part of DSL modem chipset

  – Requires additional communication channels between different lines

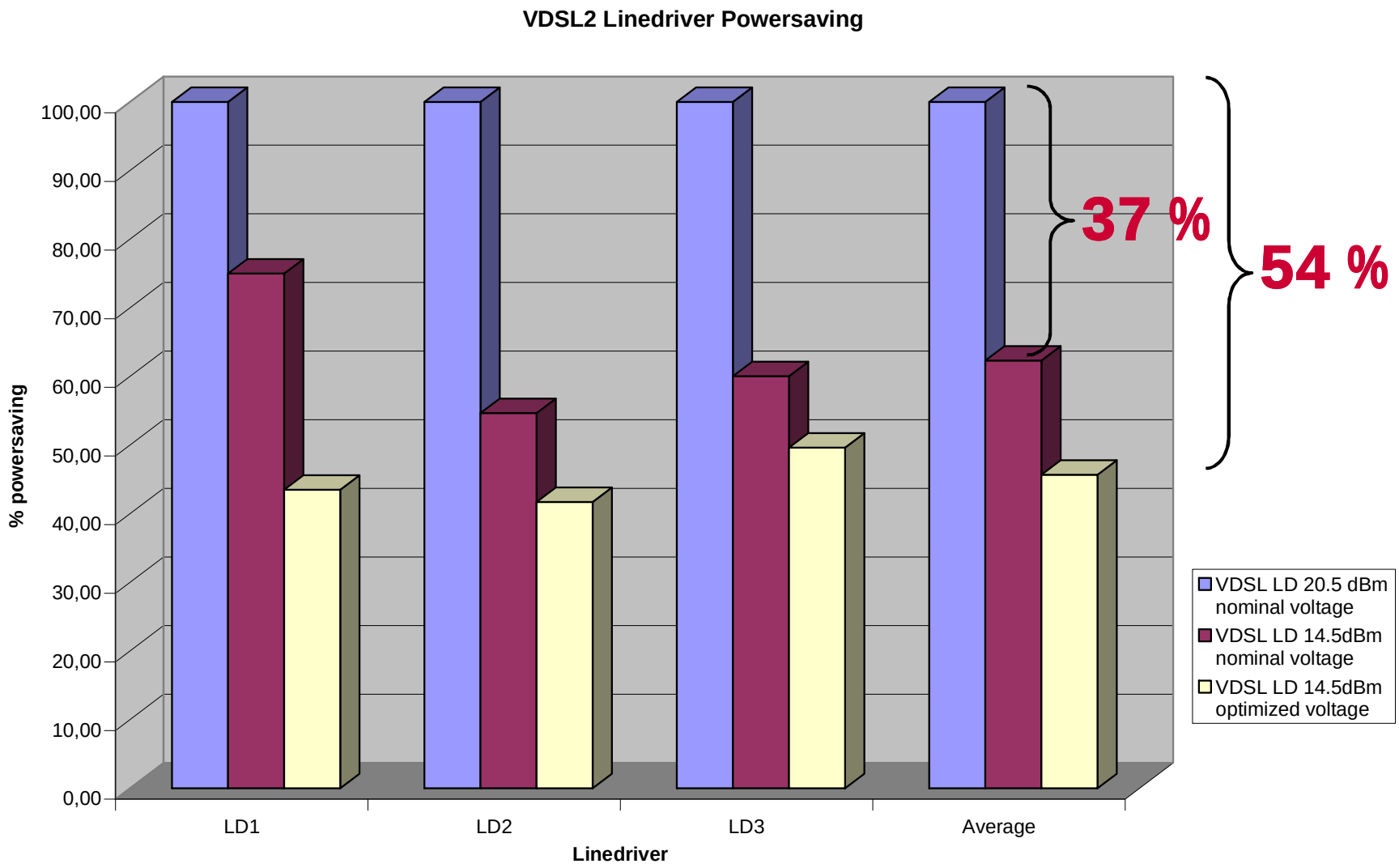
Why maximum line power?

- Previous DSLAM power figures are based on maximum power profiles
  - Up to 20 dBm (100 mW) put into the line
- Reduction of line power is possible
  - Line conditions allow for lower power
  - Regulatory restrictions force to lower line power
- What power saving is possible?

Power saving through reduced line-power for ADSL2(plus)



VDSL2 Line driver Power saving



Line power reduction

- Line power reduction from 20 dBm to 14.5 dBm gives 35 to 40 % line driver power reduction

  At system level this results in up to 20 % power reduction

- Line power reduction has impact on performance (rate/reach)

  Rate/Reach impact for ADSL2plus shown on next slide

  – Up to 5000 feet no significant impact

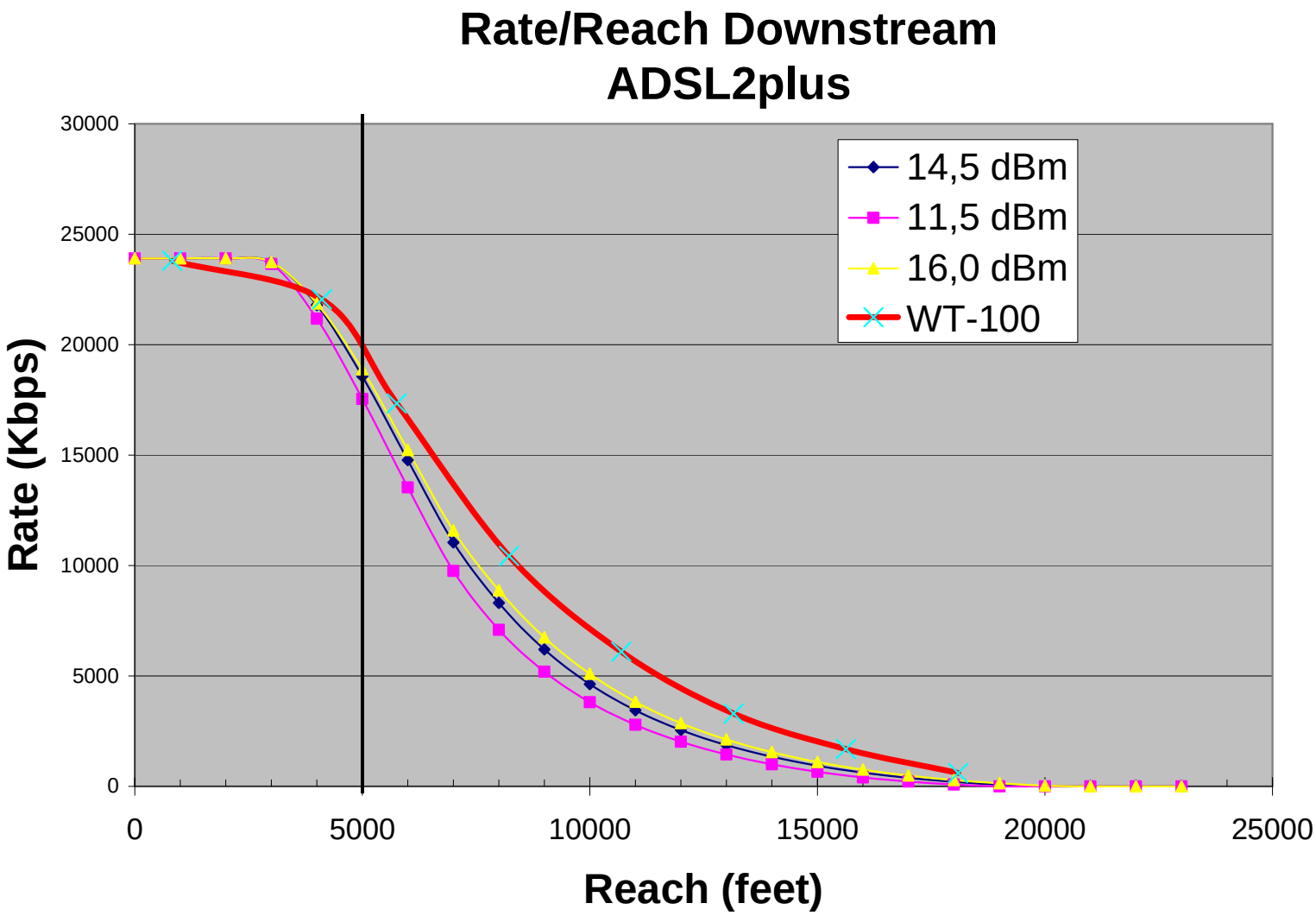
  Acceptable for cabinet/MDU deployment

- For VDSL2: profiles have been defined with line power limits

  Optimising line card for subset of VDSL2 profiles results in additional power saving

  Is high line power support on VDSL2 line card required?

Rate/Reach impact with reduced line power (ADSL2plus)



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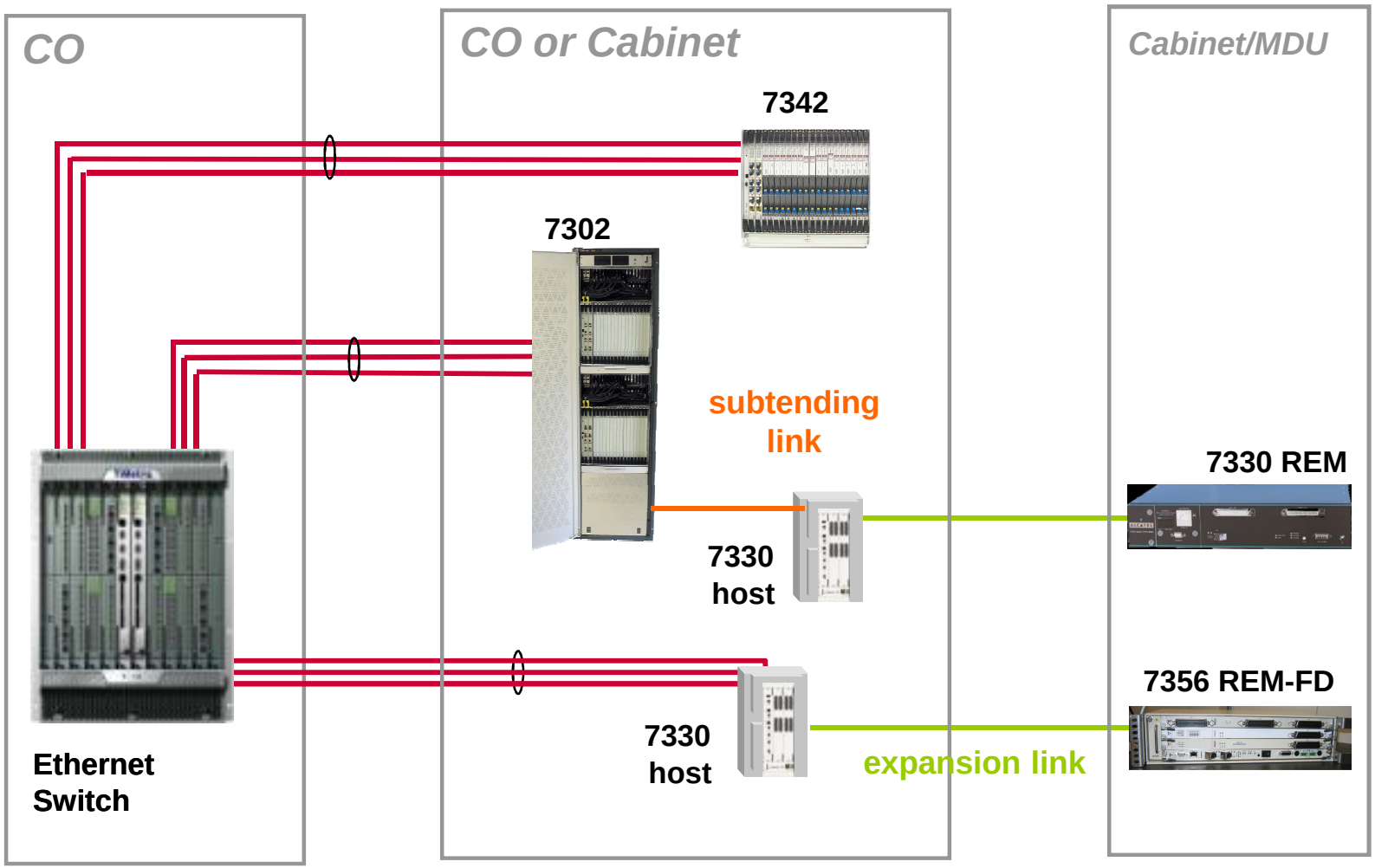
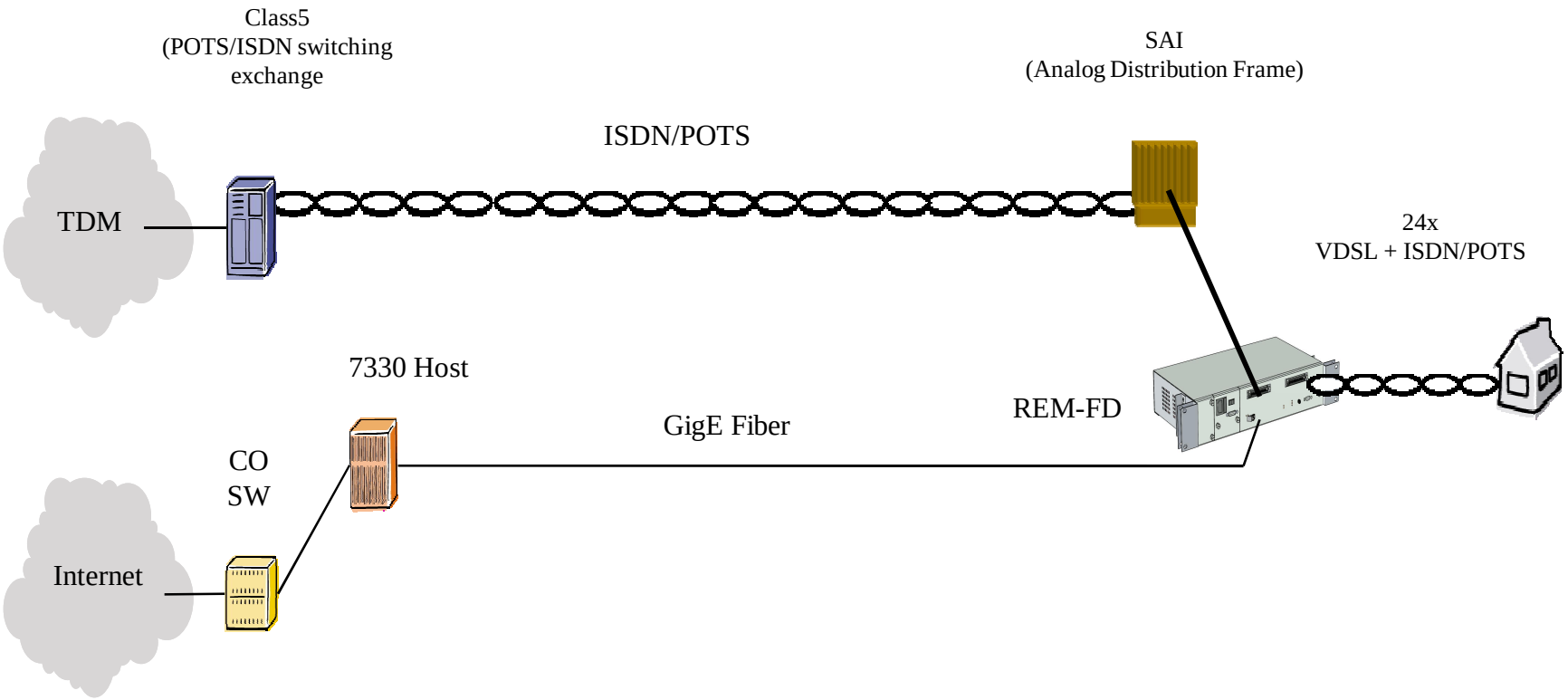
Evolving Network topology

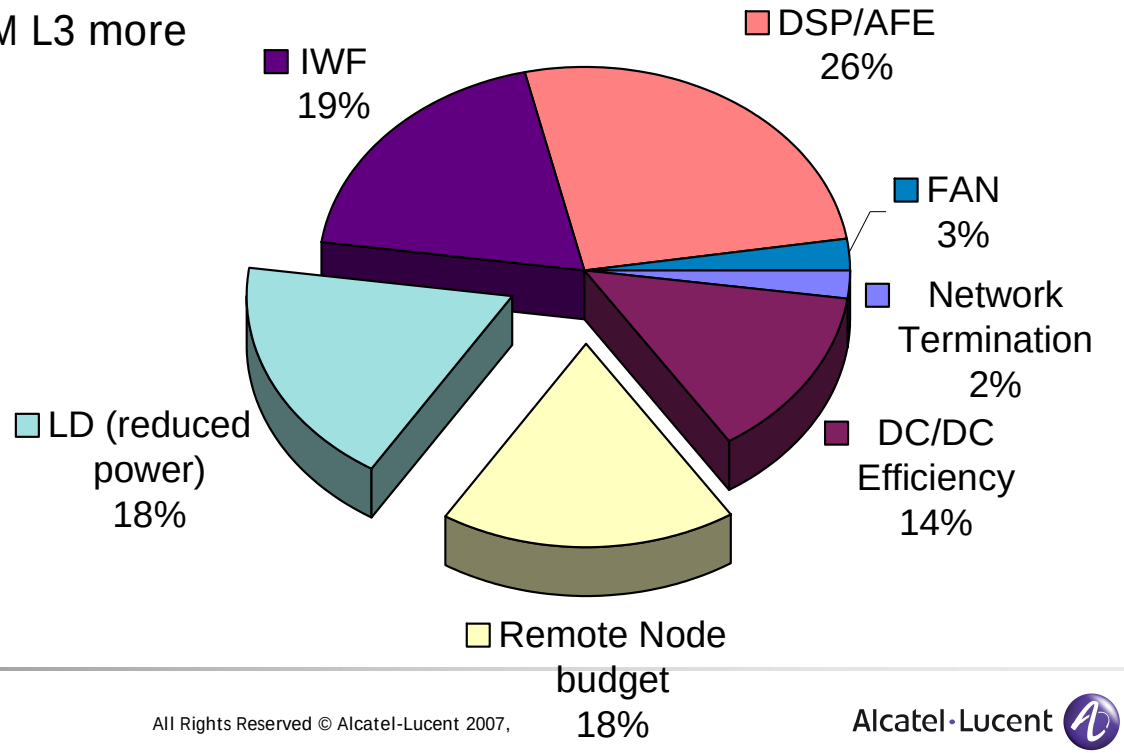


7356 REM-FD customer deployment



Evolving Network topology

- The DSLAM is moving closer to the end-user
  - Smaller nodes
  - Shorter loop lengths
- Offers opportunities for power saving
  - Introduction of line card with optimised profile feature set
    - Line driver optimisation
  - Smaller nodes might make DSM L3 more feasible then from CO



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Conclusion

Reduction of power consumption of Broadband equipment is mandatory

- To reduce the OPEX for the operator
- To allow higher density equipment and more robust remote nodes

Power consumption of Broadband equipment can and will go down in the future

- More optimal use of the line power
- Further integration/introduction of smaller ASIC technology

Will it go as low as everybody wants?

- Technical hurdles need time to be solved

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